Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Manchester Spring Chinook Broodstock Project

Bonneville project number, if an ongoing project 9606700

Business name of agency, institution or organization requesting funding
National Marine Fisheries Service

Business acronym (if appropriate) NMFS

Proposal contact person or principal investigator:

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Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name
N/A			

NPPC Program Measure Number(s) which this project addresses.
7.4D.1

NMFS Biological Opinion Number(s) which this project addresses.

Other planning document references.
Proposed Recovery Plan for Snake River Salmon (4.1.b., 4.1.c: Schmitten et al. 1995; Chapter 7: Schmitten et al. 1997)

Subbasin.
Upper Salmon River Basin (ID), Grande Ronde River Basin (OR)

Short description.
Rear Snake River spring/summer chinook salmon captive broodstocks from Idaho's Salmon River sub-basin and Oregon's Grande Ronde River sub-basin. Provide pre-spawning adults, eyed eggs, and juveniles to aid recovery of these ESA-listed stocks.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction		Watershed
	Resident fish		O & M		Biodiversity/genetics
	Wildlife	X	Production		Population dynamics
	Oceans/estuaries	+	Research		Ecosystems
	Climate		Monitoring/eval.		Flow/survival
	Other		Resource mgmt		Fish disease
			Planning/admin.	X	Supplementation
			Enforcement		Wildlife habitat enhancement/restoration
			Acquisitions		

Other keywords.
Endangered Species Act, recovery program

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
9700100	Captive Rearing Initiative for Salmon River Chinook Salmon	Idaho Department of Fish and Game is also maintaining captive broodstocks for Salmon River sub-basin populations of Snake River spring/summer chinook salmon to avoid catastrophic loss of the gene pool and for rebuilding efforts
9604400	Grande Ronde Basin Spring Chinook Captive Broodstock Program	Oregon Department of Fish and Wildlife is also maintaining captive broodstocks for Grande Ronde River sub-basin populations of Snake River spring/summer chinook salmon to avoid catastrophic loss of the gene pool and for rebuilding efforts
9305600	Assessment of captive broodstock technology	Refinement of captive broodstock technology is necessary to maximize potential of captive broodstock recovery programs for ESA-listed stocks of Pacific salmon in the

		Columbia River Basin

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Endangered Snake River spring/summer chinook salmon captive broodstock rearing	a	Salmon River Idaho stocks
2	Endangered Snake River spring/summer chinook salmon captive broodstock rearing	a	Grande Ronde River Oregon stocks

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	8/1996	7/2001	50.00%
2	8/1996	7/2001	50.00%
			TOTAL 100.00%

Schedule constraints.
Schedule may be constrained by population viability of ESA-listed stocks in this recovery program. If population numbers are still low by the year 2001, then captive broodstocks may have to be continued to protect the gene pools.

Completion date.
2001, or beyond (see schedule constraints above)

Section 5. Budget

FY99 budget by line item

Item	Note	FY99

Personnel		$78,200
Fringe benefits		$13,500
Supplies, materials, non-expendable property		$161,100
Operations & maintenance		$ 0
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		$ 0
PIT tags	# of tags:	
Travel		$15,200
Indirect costs		$39,500
Subcontracts	includes contract employees	$142,500
Other		
TOTAL		$450,000

Outyear costs

Outyear costs	**FY2000**	**FY01**	**FY02**	**FY03**
Total budget	$500,000	$500,000	$500,000	$500,000
O&M as % of total	0.00%	0.00%	0.00%	0.00%

Section 6. Abstract

The National Marine Fisheries Service (NMFS) is maintaining captive broodstocks of ESA-listed Snake River spring/summer chinook salmon. The relatively high fecundity of anadromous Pacific salmon, coupled with potentially high survival in protective culture, should allow captive broodstocks to produce large numbers of adults and juveniles to help "jumpstart" depleted populations. Implementation and refinement of captive broodstocks for the recovery of Snake River spring/summer chinook salmon are identified as a priorities in the NWPPC Columbia Basin Fish and Wildlife Program and the NMFS proposed Recovery Plan for Snake River. The NMFS captive broodstock program for Snake River spring/summer chinook salmon focuses on stocks from Idaho's upper Salmon River sub-basin and Oregon's Grande Ronde River sub-basin, is complementary to programs of the Idaho Department of Fish and Game (IDFG) and the Oregon Department of Fish and Game (ODFW), and together are intended to reduce the risk of catastrophic loss of these valuable gene pools. Currently, the program concentrates on 1994- and 1995-brood captured as juveniles from the wild by IDFG and ODFW and transferred as smolts to a pumped, filtered, and ultraviolet-light sterilized seawater system at the NMFS Manchester Marine Experimental Station. Over the next few years, it is anticipated that similar groups of fish from streams within the sub-basins will be transferred to Manchester on a yearly basis. Survivals of 1994-brood at

Manchester range from 77-93% and survivals of 1995-brood range from 76-95%. Milt from both age-2 and age 3 male fish have been cryopreserved for use in future matings. In addition, some maturing age-3 Idaho fish have been released to their natal streams. The majority of the 1994- and 1995-broods are expected to mature in 1998 and 1999, respectively.

Section 7. Project description

a. Technical and/or scientific background.

Snake River spring/summer chinook salmon (*Oncorhynchus tshawytscha*) are listed as threatened under the U.S. Endangered Species Act (ESA) (Matthews and Waples 1991). In spring 1995, the Idaho Department of Fish and Game (IDFG) and the Oregon Department of Fish and Wildlife (ODFW) initiated captive broodstocks as part of conservation efforts for ESA-listed stocks of Snake River spring/summer chinook salmon (*Oncorhynchus tshawytscha*). Oregon's Snake River spring/summer chinook salmon captive broodstock program currently focuses on three stocks captured as juveniles from the Grande Ronde River Basin: the upper Grande Ronde River, Catherine Creek, and the Lostine River. Idaho's Snake River program includes three stocks captured as juveniles from the Salmon River Basin: the Lemhi River, East Fork Salmon River, and West Fork Yankee Fork. The majority of captive fish from each stock (75-300 fish/stock) are grown to maturity in freshwater at the ODFW Bonneville Hatchery (under BPA Project 9604400) and the IDFG Eagle Hatchery (under BPA Project 9700100). However, the IDFG and ODFW requested that a portion of most groups (75-150 fish/selected stock) also be reared in protective culture in seawater. In August 1996, NMFS began a BPA funded project (Project 9606700) to rear Snake River spring/summer chinook salmon captive broodstocks in seawater at the NMFS Manchester Marine Experimental Station. These programs are authorized by NMFS ESA Section 10 Propagation Permits for rearing of Idaho (Permit 972) and Oregon (Permit 973) stocks of ESA-listed Snake River spring/summer chinook salmon.

Implementation and refinement of captive broodstocks for the recovery of Snake River spring/summer chinook salmon are identified as a priorities in the NWPPC Columbia Basin Fish and Wildlife Program (7.4D.1, 7.4D.2: CBFWP 1994) and the NMFS proposed Recovery Plan for Snake River salmon (4.1b, 4.1c: Schmitten et al. 1995; Chapter 7-P. 102 &104-106: Schmitten et al. 1997). Restoration mandates by the ESA are focused on natural populations and the ecosystems upon which they depend. Nevertheless, the ESA recognizes that conservation of listed species may be facilitated by artificial means while factors impeding population recovery are rectified (Hard et al. 1992). Frequently, restoration of severely depleted populations will be hindered for lack of suitable numbers of juveniles for effective supplementation (i.e., release of hatchery-propagated fish to increase natural production), even if factors impeding recovery could be corrected (Flagg et al. 1995a). For restoration of these populations to occur in a timely fashion, the full reproductive potential of Pacific salmon must be harnessed in the short-term to produce large numbers of juveniles. Often the only reasonable avenue to build populations quickly enough to avoid extinction will be through captive broodstock technology (Flagg and Mahnken 1995).

Captive propagation of animals to maximize their survival and reproductive potential has won acceptance in endangered species restoration (Gipps 1991, Johnson and Jensen 1991, DeBlieu 1993, Olney et al. 1994, Flagg and Mahnken 1995). Currently, over 105 species of mammals, 40 species of birds, 12 species of reptiles, 29 species of fish, and 14 species of invertebrates are being maintained or enhanced through forms of captive breeding (CBSG 1991). These efforts range from establishment of free-roaming breeding colonies on localized preserves to full-term captive rearing (Gipps 1991, Johnson and Jensen 1991, DeBlieu 1993, Olney et al. 1994, Flagg et al. 1995b). Full-term rearing of captive broodstocks maximizes potential production of juveniles for enhancement. The relatively short generation time of Pacific salmon and their potential to produce large numbers of offspring make them suitable for captive broodstock rearing. Survival advantages offered through protective culture can be significant. Theoretically, survival of fish reared in protective captive broodstock culture can exceed wild survival by as much as 100-to-1,000 fold (Flagg et al. 1995b). The substantial survival advantage for captive-reared fish provides potential to produce large numbers of juveniles to amplify the natural population during the second generation.

Even though captive broodstock theory is promising, artificial propagation and captive broodstock technologies are not without risks. There is limited data regarding the effects of broodstock manipulations (e.g., sourcing, mating, rearing, feeding, and release strategies) on the health, physiology, or genetic stability of the population, or, most importantly, on reproductive performance (Flagg and Mahnken 1995). The potential hazards of using captive culture (inbreeding, genetic drift, domestication, selection, behavioral conditioning, and exposure to disease) and the negative interactions of hatchery and wild fish have been well documented (Hynes et al. 1981, Krueger et al. 1981, Kincaid 1983, Allendorf and Ryman 1987, Kapunscinski and Jacobson 1987, Waples 1991). However, waiting for restoration of natural production is often a more dangerous risk because the entire population is threatened. The continued decline in population size risks additional loss of genetic variability and possible extinction of the population (Kincaid 1993).

Two captive broodstock approaches are being applied to salmon recovery in the Pacific Northwest. One strategy involves capturing wild prespawning adults, fertilized eggs, or juveniles from their native habitats, and rearing the populations to maturity in hatcheries. The first or second generation offspring are then stocked into ancestral lakes or streams at one or more juvenile life stages (e.g., fry, parr, smolt). Another strategy involves rearing the broodstock in captivity to adulthood, then releasing the adults back into their natal habitats to spawn naturally. Both strategies require extended culture to adulthood.

Captive broodstock survival to adulthood can vary from low to high. Past broodstock survivals have ranged 0-90% (Flagg et al. 1995b). The major disease problem noted in most captive broodstock programs has been bacterial kidney disease, caused by *Renibacterium salmoninarum*. Disease problems can be reduced considerably when fish are cultured in water with low concentrations of pathogens (e.g., fresh well water or filtered and sterilized seawater) rather than in seawater net-pens (Flagg et al. 1995b). Using optimum culture techniques (e.g., pathogen free water and low density culture), fishery managers can currently anticipate survivals of 50-80% in captive broodstocks (Schiewe et al. 1997).

The dramatic difference between the natural environments experienced by wild Pacific salmon and the artificial environments experienced by captively-reared fish appears to create a number of differences in their relative reproductive potential. In general, captively-reared Pacific salmon appear less reproductively fit than their wild cohorts. The size and age of maturity of captively-reared adults are generally less than wild cohorts (Flagg et al. 1995b, Schiewe et al. 1997). Part of this size discrepancy can be attributed to early maturity of captively-reared fish. However, even in cases where age at maturity of captively-reared fish mimicked wild fish, their size was generally 20-50% less than wild stock (Flagg et al. 1995b, Schiewe et al. 1997). Average viability of eggs from captively-reared spawners (30-70%) is also commonly lower than the 75-95% viability of similar strains of hatchery-spawned wild fish (Flagg et al. 1995b, Schiewe et al. 1997). Behavioral studies indicate that captively-reared coho salmon released to spawn in streams may also have lower breeding success than commingling wild coho salmon (Berejikian et al. in press).

The reasons for the generally poorer reproductive performance of artificially propagated captively-reared fish compared to ocean ranched and wild cohorts are not well understood. Most captive broodstock programs use spawners collected from the wild population. Therefore, it seems intuitive that much of the poor performance, at least in first-generation offspring, can be attributed to the effects of artificial culture environments. However, the effects of genetic change in the captively-reared populations as a basis for reduced spawner size, egg viability, and reproductive behavior fish remain a possibility. Ongoing research being conducted under BPA Project 9305600 to refine captive broodstock technology should provide methodologies to improve broodstock performance in the future.

Although in many cases, viability of captive broodstocks have not entirely met expectations, they still are fulfilling most supplementation goals. For instance, a captive broodstock has been developed to aid recovery of ESA-listed endangered Redfish Lake (Idaho) sockeye salmon (Flagg et. al. 1995a). Since 1991, a total of only 15 sockeye salmon adults have returned to Redfish Lake; all have been captured and spawned for captive broodstocking purposes. NMFS captive broodstock efforts for this endangered species (BPA Project 9204000) has resulted in over 600,000 viable eggs produced and returned to Idaho for use in recovery efforts; a direct amplification of over 175 times the endangered species gametes taken into protective culture (T. A. Flagg, NMFS, unpubl.

data). Similarly, White River captive broodstocks (Appleby and Keown 1995) are now producing almost a million eggs a year for enhancement (K. Keown, Washington State Department of Fisheries and Wildlife, pers. commun., 1997).

Captive broodstock technology for salmonids, although still in its initial development stages, appears sufficiently advanced to allow carefully planned programs to proceed. Viability of captively-reared spawners may be less than wild fish. Nevertheless, captive broodstock programs have the potential to provide the amplification necessary to both reduce extinction risk and begin recovery measures for depleted stocks. It is clear that captive broodstocks cannot be a substitute for restoring fish in the habitat. However, it appears unrealistic to rely solely on habitat improvements and harvest restrictions to affect recovery, especially when populations have reached critically low numbers. For severely depleted populations, captive broodstocks will often be the only method to rebuild numbers quickly enough to reduce inbreeding or avoid extinction.

b. Proposal objectives.

The proposal objectives for BPA Project 9606700 are to: (1) Rear Snake River spring/summer chinook salmon captive broodstocks from Idaho’s Salmon River sub-basin (75-100 fish from each of up to three stocks) and Oregon’s Grande Ronde River sub-basin (150 fish from each of up to three stocks) and, (2) Provide pre-spawning adults, eyed eggs, and juveniles to aid recovery of these ESA-listed stocks in Idaho and Oregon.

Testable hypotheses include: If Snake River spring/summer chinook salmon captive broodstocks will produce prespawning adults and gametes in sufficient numbers and of sufficient quality to aid recovery efforts. Ho: no prespawning adults or eggs produced. H1: prespawning adults and eggs will be produced in sufficient numbers and quality. H2: prespawning adults and eggs will be produced, but in insufficient numbers and quality.

The alternate approach to captive broodstock intervention for Snake River spring/summer chinook salmon may be extinction of these ESA-listed stocks.

Critical uncertainties include: (1) Whether Snake River spring/summer chinook salmon captive broodstocks will produce prespawning adults and gametes in sufficient numbers and of sufficient quality to aid recovery efforts; and (2) If habitat improvements in nursery areas and in the migration corridor will occur to allow natural long-term increases in population replacement rate.

Expected products include: (1) The captive broodstock programs should provide hundreds of adults and hundreds of thousands of eggs for use in recovery efforts; (2) Maintaining geographically separate captive brood populations (at the IDFG Eagle Hatchery, ODFW Lookingglass and Bonneville Hatchery, and NMFS Manchester Marine Experimental Station) will help reduce the risk of catastrophic loss of gene pools from mechanical failure, human error, or disease; (3) Annual progress reports to BPA. In addition, information from projects related to recovery efforts for ESA-listed Snake River spring/summer chinook salmon are being coordinated through the BPA chaired Snake River Chinook Salmon Captive Propagation Technical Oversight Committee (CSCPTOC). Membership on the CSCPTOC includes NMFS, BPA, IDFG, ODFW, U.S. Fish and Wildlife Service (USFWS) Lower Snake River Compensation Office, Shoshone-Bannock and Nez Perce Tribes, and other state and federal agencies and private groups interested in spring/summer chinook salmon restoration in the Snake River basin areas of Idaho and Oregon.

c. Rationale and significance to Regional Programs.

Snake River spring/summer chinook salmon (*Oncorhynchus tshawytscha*) are listed as threatened under the U.S. Endangered Species Act (ESA) (Matthews and Waples 1991). For restoration of these populations to occur in a timely fashion, the full reproductive potential of Pacific salmon must be harnessed in the short-term to produce large numbers of juveniles. Often the only reasonable avenue to build populations quickly enough to avoid extinction will be through captive broodstock technology (Flagg and Mahnken 1995). The objectives for BPA Project 9606700 follow the priority guidelines for implementation and refinement of captive broodstocks for the recovery of Snake River spring/summer chinook salmon identified in the NWPPC Columbia Basin Fish and Wildlife Program (7.4D.1, 7.4D.2: CBFWP 1994) and the NMFS proposed Recovery Plan for Snake River salmon (4.1b, 4.1c: Schmitten et al. 1995; Chapter 7-P. 102 &104-106: Schmitten et al. 1997).

Captive broodstock programs are a form of artificial propagation where fish are cultured in captivity for most or all of their life cycle. The relatively high fecundity of anadromous Pacific salmon, coupled with potentially high survival in protective culture, should allow captive broodstocks to produce large numbers of adults and juveniles to help "jumpstart" depleted populations. Maintaining geographically separate captive brood populations (at the IDFG Eagle Hatchery: BPA Project 9700100, ODFW Lookingglass and Bonneville Hatchery: BPA Project 9604400, and NMFS Manchester Marine Experimental Station: BPA Project 9606700) will help reduce the risk of catastrophic loss of gene pools from mechanical failure, human error, or disease. Research to refine captive broodstock technology (BPA Project 9305600) should help improve broodstock performance and maximize their contribution to recovery goals. In upcoming years, the captive broodstock programs should provide hundreds of adults and hundreds of thousands of eggs for use in recovery efforts in Idaho and Oregon.

NMFS is coordinating captive broodstock efforts for BPA Project 9606700 through the BPA chaired Snake River Chinook Salmon Captive Propagation Technical Oversight Committee (CSCPTOC). Membership on the CSCPTOC includes NMFS, BPA, IDFG, ODFW, U.S. Fish and Wildlife Service (USFWS) Lower Snake River Compensation

Office, Shoshone-Bannock and Nez Perce Tribes, and other state and federal agencies and private groups interested in spring/summer chinook salmon restoration in the Snake River basin areas of Idaho and Oregon.

d. Project history

1. Project numbers - BPA Project 9606700 (unchanged)

2. Project reports:

Flagg, T. A., M. R. Wastel, and W. C. McAuley. 1996. Manchester spring chinook broodstock project, progress report - August 1996-November 1996. Quarterly report to Bonneville Power Administration, Contract 96-BI-96441. 9 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112.)

Flagg, T. A., M. R. Wastel, and W. C. McAuley. 1997. Manchester spring chinook broodstock project, progress report - December 1996-March 1997. Quarterly report to Bonneville Power Administration, Contract 96-BI-96441. 7 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112.)

Flagg, T. A., M. R. Wastel, and W. C. McAuley. 1998. Manchester spring chinook broodstock project, progress report - April 1997-December 1997. Quarterly report to Bonneville Power Administration, Contract 96-BI-96441. 7 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112.)

3. Summary of major results achieved: In spring 1995, the Idaho Department of Fish and Game (IDFG) and the Oregon Department of Fish and Wildlife (ODFW) initiated captive broodstocks as part of conservation efforts for ESA-listed stocks of Snake River spring/summer chinook salmon (*Oncorhynchus tshawytscha*). Oregon's Snake River spring/summer chinook salmon captive broodstock program currently focuses on three stocks captured as juveniles from the Grande Ronde River Basin: the upper Grande Ronde River, Catherine Creek, and the Lostine River. Idaho's Snake River program includes three stocks captured as juveniles from the Salmon River Basin: the Lemhi River, East Fork Salmon River, and West Fork Yankee Fork. The majority of captive fish from each stock (75-300 fish/stock) are grown to maturity in freshwater at the ODFW Bonneville Hatchery (under BPA Project 9604400) and the IDFG Eagle Hatchery (under BPA Project 9700100). However, the IDFG and ODFW requested that a portion of most groups (75-150 fish/selected stock) also be reared in protective culture in seawater. In August 1996, NMFS began a BPA funded project (Project 9606700) to rear Snake River

spring/summer chinook salmon captive broodstocks in seawater at the NMFS Manchester Marine Experimental Station. These programs are authorized by NMFS ESA Section 10 Propagation Permits for rearing of Idaho (Permit 972) and Oregon (Permit 973) stocks of ESA-listed Snake River spring/summer chinook salmon.

Currently, BPA Project 9606700 concentrates on 1994- and 1995-brood captured as juveniles from the wild by IDFG and ODFW and transferred as smolts to a pumped, filtered, and ultraviolet-light sterilized seawater system at the NMFS Manchester Marine Experimental Station. Survivals of 1994-brood at Manchester range from 77-93% and survivals of 1995-brood range from 76-95%. Male age-2 precocity has ranged from about 1-5% for Idaho stocks and 4-9% for Oregon stocks. Male age-3 jack production has ranged from about 3-22% for Idaho stocks and 10-23% for Oregon stocks. Milt from both age-2 and age 3 male fish have been cryopreserved for use in future matings. In addition, some maturing age-3 Idaho fish have been released to their natal streams (under BPA Project 9700100). The majority of the 1994- and 1995-broods expected to mature in 1998 and 1999, respectively should provide hundreds of adults and hundreds of thousands of eggs for use in recovery efforts in Idaho and Oregon.

4. Adaptive management implications: For severely depleted populations, captive broodstocks will often be the only method to rebuild numbers quickly enough to reduce inbreeding or avoid extinction.

5. Years underway: since 1996.

6. Past costs: FY 1996 - $481,400; FY 1997 - $501,000

e. Methods.

The captive broodstock concept differs from that used in conventional hatcheries in that fish of wild origin are maintained in captivity throughout their life. Offspring from captive broodstocks are released to supplement wild populations. The high fecundity of Pacific salmon, coupled with potentially high survival in protective culture, affords an opportunity for captive broodstocks to produce large numbers of juveniles in a single generation for supplementation. The relatively stable egg supply provided through a captive broodstock program should help ensure success of supplementation efforts for depleted stocks.

The majority of captive fish from each stock (75-300 fish/stock) are grown to maturity in freshwater at the ODFW Bonneville Hatchery (under BPA Project 9604400) and the IDFG Eagle Hatchery (under BPA Project 9700100). However, the IDFG and ODFW requested that a portion of most groups (75-150 fish/selected stock) also be reared in protective culture in seawater. In May-June 1996, IDFG and ODFW transferred groups of 1994-brood Snake River spring/summer chinook salmon smolts to Manchester for rearing to adult. In late May 1997, Idaho transferred 1995-brood fish to Manchester. In mid June 1997, Oregon transferred 1995-brood fish to Manchester. Similar efforts are planned for subsequent year-classes of fish. To date, survival during culture has been excellent (>75%) for all 1994- and 1995-brood groups of fish. NMFS anticipates receiving groups of 1996-brood fish from Idaho and Oregon in spring 1998.

NMFS is providing daily staffing for protective culture of Snake River spring/summer chinook salmon at Manchester. Staffing during some weekends and holidays may be covered by drop-in site inspections. Groups of Snake River spring/summer chinook salmon are being reared to maturity in 4.1-m to 6.1-m diameter circular fiberglass tanks supplied with filtered and sterilized seawater. Fish are housed in a protective rearing building equipped with electronic security. Electronic security and facilities monitoring is provided at all times.

Husbandry requirements are detailed in ESA Section 10 Propagation Permits for rearing of Idaho (Permit 972) and Oregon (Permit 973) stocks of ESA-listed Snake River spring/summer chinook salmon (Available from National Marine Fisheries Service, 525 N.E. Oregon, Suite 500, Portland, OR 97232-2737). The fish are reared using standard fish culture practices and approved therapeutics (for an overview of standard methods see Piper et al. 1982, Leitritz and Lewis 1976, Rinne et al. 1986). Generally, juvenile-to-adult rearing density in the tanks will be maintained at under 8 kg/m^3 (0.5 lbs/ft^3) during most of the culture period; however, fish density may range to 15 kg/m^3 (1.0 lbs/ft^3) at maturity. Fish will be fed a commercial ration (e.g., Biodiet) during culture. Appropriate prophylactic drugs are administered under supervision of a veterinarian during fish rearing. For instance, the diet is modified under FDA New Investigational Animal Drug (INAD) 4333 to contain 0.45% erythromycin and fed at 2% of body weight/day for 28 d on a quarterly basis during rearing as a prophylatic for bacterial pathogens. Mortalities will be examined to determine cause of death. Select mortalities will be frozen or preserved as appropriate for genetic or other analyses. Appropriate statistical analysis will be conducted to compare growth, survival, and reproductive success of stocks of fish from the Salmon and Grande Ronde River sub-basins. NMFS is coordinating exact details of rearing parameters for these fish with ODFW and IDFG through the Snake River Chinook Salmon Captive Propagation Technical Oversight Committee (CSCPTOC) process.

Idaho has proposed an approach, termed captive rearing, that involves rearing broodstock in captivity to adulthood and releasing them back into their natal streams to spawn naturally. This approach is untried and it is unclear whether hatchery-reared adults will retain the characteristics necessary for successful spawning in the wild. Because success of achieving wild-fish attributes is uncertain, it is possible that gametes may also be returned to Idaho to help maintain these gene pools. Oregon has proposed a conventional captive breeding approach where maturing fish would be returned to Oregon, spawned, and the resultant eggs used to help maintain and restore these gene pools.

f. Facilities and equipment.

BPA Project 9606700 is being conducted at the NMFS Manchester Marine Experimental Station. The Station is situated on Clam Bay, a small bay adjoining the central basin of Puget Sound. The station is located on nine hectares of land surplused from the U.S. Navy to NMFS in the late 1960s. The main building at the Manchester Station contains three laboratories, seven offices, and computer and conference rooms. Adjoining the main building is a smaller disease diagnostic laboratory containing a pathology lab, a bioassay lab, and two offices. A new land-based seawater captive broodstock rearing complex at the Station contains three offices, and wet and dry labs, and 400 m^2 of floor space for fish rearing tanks in one building and 1,280 m^2 in another.

A major advantage of the site is the excellent seawater quality. Clam Bay is a major tidal mixing zone between Sinclair and Dyes Inlets to the west and waters of central Puget Sound to the east. Annual seawater temperature at the site normally ranges from 7-13^oC and salinity ranges between about 26-29 ppt. The high quality seawater environment, combined with a 250-m pier made available to the station by the EPA Region X Laboratory, make the Manchester Station an excellent site for experimentation/culture of a variety of finfish and shellfish.

A 700-m-long pipeline from the end of the pier supplies about 6,000 L/min (1, 500 gpm) of pumped seawater to the Station's land-based facilities. Water is pumped via 50-hp centrifugal pumps. The system is outfitted with 50-hp back-up pumps in case of primary pump failure. An alarm system monitors the pumps and electrical supply and is tied into an automatic dialer system linked to pagers and home and office telephones. Redundant emergency generators are automatically serially activated in the event of a power failure.

The 400 m^2 seawater laboratory contains six 4.1-m and three 1.8-m diameter circular fiberglass tanks. The building with 1,280 m^2 of floor space was built specifically for chinook salmon captive broodstock rearing for BPA Project 9606700 and is designed to contain 20 6.1-m diameter circular fiberglass tanks. The seawater supplied to these tanks is processed to ensure quality. Filtering consists of primary sand filters containing number 20-grade sand; this filters out all organic and inorganic material more than 20 microns in diameter. Water exiting the sand filters immediately enters a secondary cartridge filter system capable of filtering out all material more than 5 microns in diameter. The water then passes through UV-sterilizers to inactivate remaining organic material. Flow and pressure sensors monitor flow through the seawater filtration/sterilization system. A chiller system will be installed in 1998 to provide temperature controlled seawater to 6.1-m diameter circular fiberglass tanks containing maturing fish.

Before entering fish rearing tanks, the processed seawater is passed through packed column degassers to strip out any excess nitrogen and to boost dissolved oxygen levels. Any interruption in water flow activates an emergency oxygen supply to all rearing containers. The Station complies with Washington State quarantine certification standards and all water exiting captive broodstock rearing areas is depurated.

The unique seawater rearing facilities and staff expertise make the Station an ideal facility for conducting captive broodstock rearing and research projects.

g. **References**.

Allendorf, F. W. and N. Ryman. 1987. Genetic management of hatchery stock: past, present, and future. *In* N. Ryman and F. Utter (editors), Population genetics and fisheries management, p. 141-159. Univ. Washington Press, Seattle.

Appleby, A., and K. Keown (editors). 1994. History of White River spring chinook broodstocking and captive brood rearing efforts. *In* T. A. Flagg and C. V. W. Mahnken (editors), An assessment of the status of captive broodstock technology for Pacific Salmon, Chapter 6. Report to the Bonneville Power Administration, Contract DE-BI79 93BP55064. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112.)

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Kincaid, H. L. 1993. Breeding plan to preserve the genetic variability of the Kootenai River white sturgeon. Report to Bonneville Power Administration, Contract DE-AI79 93BP02886, 18 p. (Available from Bonneville Power Administration, Box 3621, Portland, OR 97208.)

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Rinne, J. N., J. E. Johnson, B. L. Jensen, A. W. Ruger, and R. Sorenson. 1986. The role of hatcheries in the management and recovery of threatened and endangered fishes. *In* R. H. Stroud (editor), Fish culture in fisheries management, p. 271-285. Proceedings of a symposium on the role of fish culture in fisheries management. Am. Fish. Soc., Bethesda, Maryland, 479 p.

Schiewe, M. H., T. A. Flagg, and B. A. Berejikian. 1997. The use of captive broodstocks for gene conservation of salmon in the western United States. Bull. Natl. Res. Inst. Aquacult., Suppl. 3:29-34.

Schmitten, R., W. Stelle, Jr., and R. P. Jones. 1995. Proposed Recovery Plan for Snake River Salmon. 347 p., plus appendices. (Available from National Marine Fisheries Service, 525 N.E. Oregon, Suite 500, Portland, OR 97232-2737.)

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Section 8. Relationships to other projects

In spring 1995, the Idaho Department of Fish and Game (IDFG) and the Oregon Department of Fish and Wildlife (ODFW) initiated captive broodstocks as part of conservation efforts for ESA-listed stocks of Snake River spring/summer chinook salmon (*Oncorhynchus tshawytscha*). The need for this captive broodstock strategy was identified as critical in the National Marine Fisheries Service (NMFS) Proposed Recovery Plan for Snake River Salmon. Oregon's Snake River spring/summer chinook salmon captive broodstock program currently focuses on three stocks captured as juveniles from the Grande Ronde River Basin: the upper Grande Ronde River, Catherine Creek, and the Lostine River. Idaho's Snake River program includes three stocks captured as juveniles from the Salmon River Basin: the Lemhi River, East Fork Salmon River, and West Fork Yankee Fork. The majority of captive fish from each stock are grown to maturity in freshwater at the ODFW Bonneville Hatchery (under BPA Project 9604400) and the IDFG Eagle Hatchery (under BPA Project 9700100). A portion of most groups are reared in protective culture in seawater at the NMFS Manchester Marine Experimental Station (under BPA Project 9606700). Husbandry requirements are detailed in ESA Section 10

Propagation Permits for rearing of Idaho (Permit 972) and Oregon (Permit 973) stocks of ESA-listed Snake River spring/summer chinook salmon.

Projects related to recovery efforts for ESA-listed Snake River spring/summer chinook salmon are being coordinated through the BPA chaired Snake River Chinook Salmon Captive Propagation Technical Oversight Committee (CSCPTOC). Membership on the CSCPTOC includes NMFS, BPA, IDFG, ODFW, U.S. Fish and Wildlife Service (USFWS) Lower Snake River Compensation Office, Shoshone-Bannock and Nez Perce Tribes, and other state and federal agencies and private groups interested in spring/summer chinook salmon restoration in the Snake River basin areas of Idaho and Oregon.

Maintaining geographically separate captive brood populations (at the IDFG Eagle Hatchery, ODFW Lookingglass and Bonneville Hatchery, and NMFS Manchester Marine Experimental Station will help reduce the risk of catastrophic loss of gene pools from mechanical failure, human error, or disease. Research to refine captive broodstock technology (BPA Project 9305600) should help improve broodstock performance and maximize their contribution to recovery goals.

Section 9. Key personnel

1. Mr. Thomas A. Flagg, Fisheries Research Biologist. Principal Investigator @ 33% FTE. Duties include internal project oversight; project coordination with IDFG, ODFW, the Snake River Chinook Salmon Captive Propagation Technical Oversight Committee, and others; Data analysis and report writing; etc. [See attached resume for qualifications.]

2. Mr. Wm. Carlin McAuley, Endangered Species Biologist. Hatchery Manager @ 33% FTE. Duties include all phases of fish husbandry and hatchery oversight/coordination. [See attached resume for qualifications.]

3. Mr. Michael R. Wastel, Fisheries Biological Technical. Hatchery support staff @ 33% FTE. Duties include fish husbandry. [See attached resume for qualifications.]

4. Dr. Lee W. Harrell, Veterinarian. Fish Pathologist @ 12% FTE. Duties include oversight of fish health issues. [See attached resume for qualifications.]

CURRICULUM VITAE--**THOMAS ALVIN FLAGG**

Education: B.S. (Fisheries Biology), University of Washington, Seattle, WA; 1976.
M.S. (Fisheries Biology), University of Washington, Seattle, WA; 1981.

Employer: National Marine Fisheries Service, Northwest Fisheries Science Center, Resource Enhancement & Utilization Technologies Division.

Position: Fisheries Research Biologist, NMFS employee since 1978.

Present assignment: Team Leader, Salmon Enhancement Projects. Responsibilities include: development of captive broodstock programs to conserve depleted gene pools of salmonids; development of supplementation techniques for restoration of depleted stocks of salmonids to their native habitats; and development of fish husbandry technology to produce wild-type juvenile salmon for release from hatcheries.

Previous research/expertise: Included research associated with: determination of status of depleted stocks of fish including those proposed for listing as threatened or endangered under the Endangered Species Act; development of the passive integrated transponder (PIT) tagging system for salmonids; development of freshwater and seawater net-pen aquaculture husbandry and captive broodstock techniques for Atlantic and Pacific salmon (including research in the areas of aquaculture systems design and development, stock rearing strategies, nutrition, disease investigations, maturation and spawning, hormonal sex reversal, smoltification, and stock performance); investigation of fish-collection and transportation related mortalities in juvenile salmonids in the Columbia River system; evaluation of the impact of the 1980 Mt. St. Helens eruption on juvenile salmonids in the Columbia River system; and investigation of the relationship between swimming behavior, smoltification status, and seawater survival for coho salmon.

Mr. Flagg has participated in a number of captive broodstock programs for Pacific and Atlantic salmon. He has written a number of articles on captive broodstocks, including:

Flagg, T. A., and C. V. W. Mahnken (editors). 1995. An assessment of captive broodstock technology for Pacific salmon. Report to Bonneville Power Administration, Contract DE-AI79 93BP55064. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.)

Flagg, T. A., C. V. W. Mahnken, and K. A. Johnson. 1995. Captive broodstocks for recovery of depleted populations of Pacific salmon. Am. Fish. Soc. Symp. 15:81-90.

Flagg, T. A., F. W. Waknitz, and C. V. W. Mahnken. 1995. The captive broodstock concept: application to Pacific salmon, pp. 1-1 - 1-60 (1995b). *In* T. A. Flagg and C. V. W. Mahnken (eds.), An assessment of captive broodstock technology for Pacific salmon. Report to Bonneville Power Administration, Contract DE-AI79 93BP55064. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.)

Flagg, T. A., W. C. McAuley, M. R. Wastel, D. A. Frost, and C. V. W. Mahnken. 1996. Redfish Lake sockeye salmon captive broodstock rearing and research, 1994. Report to Bonneville Power Administration, Contract DE-AI79 92BP41841, 98 p.

Schiewe, M. H., T. A. Flagg, and B. A. Berejikian. 1997. The use of captive broodstocks for gene conservation of salmon in the western United States. Bull. Natl. Res. Inst. Aquacult., Suppl. 3:29-34.

CURRICULUM VITAE--**W. Carlin McAuley**

Education: B.S. Zoology, University of Washington, 1973.

Training: Fish Disease Control Course, Oregon State University, Marine Science Center, 80 hours, 1987.

Employer: National Marine Fisheries Service, Northwest Fisheries Science Center, Resource Enhancement & Utilization Technologies Division.

Position: Endangered Species Biologist, NMFS employee since 1991.

Present assignment: Hatchery Manager for NMFS Manchester Marine Experimental Station captive broodstock programs for recovery of ESA-listed endangered Redfish Lake sockeye salmon and threatened Snake River spring/summer chinook. Responsible for every aspect of life cycle including feed rations, disease detection and control, detailed record database, and spawning.

Previous research/expertise: Conducted research into captive broodstock programs using non endangered Lake Wenatchee sockeye salmon captive broodstock (BY 1990 and 1991) reared in three different environments. Responsible for daily care including feed, disease detection and control, detailed record database, spawning, and egg incubation. Provided support for other researchers investigating physiological developments in these same fish. Specialized skills include various fish tagging techniques (coded wire tag, PIT tag, elastomer tag, freeze branding), and Fluorescent Antibody Technique for detection of fish disease pathogens. Provided aquaculture consulting to Domsea Farms Inc. Primarily responsible for continuation of 13 year genetics breeding program for captive broodstocks of Pacific salmon at Domsea Farms. Duties consisted of management of captive breeding program of fish reared in freshwater, including collection and input of data into genetics database, tracking and maintaining separate identity of 40 families, and decision making for various program steps

Mr. McAuley has participated in a number of captive broodstock programs for Pacific salmon. He has authored or co-authored a number of articles on captive broodstocks, including:

McAuley, W. C. 1981a. DOMSEA coho broodstock program. *In* T. Nosho (editor), Salmonid broodstock maturation, p.23-24. Proceedings of the salmonid broodstock maturation workshop. University of Washington Sea Grant Pub. WSG-WO-80-1.

McAuley, W. C. 1981b. DOMSEA coho broodstock program-update. *In* T. Nosh (editor), Salmonid broodstock maturation, p.65-66. Proceedings of the salmonid broodstock maturation workshop. University of Washington Sea Grant Pub. WSG-WO-80-1.

Flagg, T. A., and W. C. McAuley. 1993. Redfish Lake sockeye salmon captive broodstock rearing and research, 1991-1993. Report to Bonneville Power Administration, Contract DE-A179-92BP41841.

Flagg, T. A., W. C. McAuley, M. R. Wastel, D. A. Frost, and C. V. W. Mahnken. 1996. Redfish Lake sockeye salmon captive broodstock rearing and research, 1994. Report to Bonneville Power Administration, Contract DE-AI79 92BP41841, 98 p.

CURRICULUM VITAE--**Michael R. Wastel**

Education: A.S. Fisheries - Peninsula College, 1977.

Training: Business College Computer Classes 1987, 1989. U.S. Fish & Wildlife Service Fish Disease Course, 1990.

Employer: National Marine Fisheries Service, Northwest Fisheries Science Center, Resource Enhancement & Utilization Technologies Division.

Position: Fisheries Biological Technician, NMFS employee since 1992.

Present assignment: Provide technician support for NMFS Manchester Marine Experimental Station captive broodstock programs for recovery of ESA-listed endangered Redfish Lake sockeye salmon and threatened Snake River spring/summer chinook. Lead contact for construction of captive broodstock research facilities for freshwater and seawater rearing at Manchester. Responsible for aspect of life cycle culture including feed rations, disease detection and control, detailed record database, and spawning.

Previous work experience/expertise: 1991-1992**--**Fisheries Technician, Steelhead Stock Assessment Program, Washington Department Fish and Wildlife, Olympia, Washington. Responsible for the collection of data on steelhead life histories for 22 Washington State rivers, all tributaries of the Columbia River. 1980-1991--Hatchery Manager, Fisheries Research Division, Domsea Farms Inc. Gorst Creek Hatchery, Gorst, Washington. Supervised and participated in all phases of hatchery operations. Responsible for all fish rearing activities. Worked on both production and broodstock programs. Supervised six employees. Assigned work schedules. Formulated fiscal budget. Produced monthly reports. Maintained hatchery systems including; wells, pumps, generators and alarm system. Expanded and upgraded hatchery incubation. Installed additional tanks. Assisted in the formation of coho salmon broodstock program which produced fish with superior growth and survival rates. As the offspring of fish from the broodstock program outperformed all other hatchery fish, the program expanded and became a major part of my responsibilities.

Mr. Wastel has participated in a number of captive broodstock projects for Pacific salmon. He has co-authored articles on fisheries and captive broodstocks, including:

Hymer, J., R. Pettit, M. Wastel, P. Hahn, and K. Hatch. 1992. Stock Summary reports for Columbia River Anadromous Salmonids, Volume 3. BPA, Division of Fish and Wildlife, Project No. 88-108.

Flagg, T. A., W. C. McAuley, M. R. Wastel, D. A. Frost, and C. V. W. Mahnken. 1996. Redfish Lake sockeye salmon captive broodstock rearing and research, 1994. Report to Bonneville Power Administration, Contract DE-AI79 92BP41841, 98 p.

CURRICULUM VITAE--**Lee W. Harrell**

Education:

- B.S. (Animal Husbandry). University of Florida, Gainesville, FL. 1960.
- D.V.M. (Veterinary Medicine). Auburn University, Auburn, AL. 1964.
- M.S. (Fisheries Biology). University of Washington, Seattle, WA. 1973.

Professional Certifications: Certified Fish Pathologist (AFS) #35; Washington State Veterinary practice license # 653; Florida State Veterinary license # 857.

Employer: National Marine Fisheries Service, Northwest Fisheries Science Center, Resource Enhancement & Utilization Technologies Division.

Position: Fisheries Research Biologist/Veterinarian, NMFS employee since 1973.

Present assignment: Manager of Fish Health projects, Manchester Experimental Station. Duties include fish disease diagnosis and treatment; conducting research on freshwater and marine diseases of salmonids; and involvement in broodstock restoration methods. Pathologist representative, Pacific Northwest Fish Health Protection Committee. Consulting Veterinarian, Washington State Department of Fisheries and Wildlife.

Previous research/expertise: Included: research associated with all phases of salmonid fish health and disease diagnosis and treatment; development of freshwater and seawater net-pen aquaculture husbandry; development of captive broodstock techniques for Atlantic and Pacific salmon. Dr. Harrell has authored or co-authored a number of articles on captive broodstocks and fish health, including:

Harrell, L. W., C. V. W. Mahnken, T. A. Flagg, E. F. Prentice, F. W. Waknitz, J. L. Mighell, and A. J. Novotny. 1984. Status of the NMFS/USFWS Atlantic salmon brood-stock program (Summer 1984). Annual report of research (to NMFS/NER). 16 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112.)

Harrell, L. W., T. A. Flagg, and F. W. Waknitz. 1987. Snake River Fall Chinook Salmon Broodstock Program, 1981-1986. Final report to Bonneville Power Administration. 24 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112.)

R. A. Elston, <u>L. W. Harrell</u>, and M. T. Wilkinson. 1986. Isolation and in vitro characteristics of chinook salmon *Oncorhynchus tshawytscha* rosette agent. Aquaculture 56:1-21.

R. A. Elston, M. L. Kent, and <u>L. W. Harrell</u>. 1987. An intranuclear microsporidium associated with acute anemia in the chinook salmon, *Oncorhynchus tshawytscha*. J. Protozool. 34(3):274 277.

Harrell, Lee W. 1995. Fish health aspects of broodstock restoration, pp. 5-1 - 5-14. *In* T. A. Flagg and C. V. W. Mahnken (eds.), An assessment of captive broodstock technology for Pacific salmon. Report to Bonneville Power Administration, Contract DE-AI79 93BP55064. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.)

Section 10. Information/technology transfer

Information/technology transfer methods will include: BPA contract reports; journal publications; participation in conferences and workshops; etc. In addition, projects related to recovery efforts for ESA-listed Snake River spring/summer chinook salmon are being coordinated through the BPA-chaired Snake River Chinook Salmon Captive Propagation Technical Oversight Committee (CSCPTOC). Membership on the CSCPTOC includes NMFS, BPA, IDFG, ODFW, U.S. Fish and Wildlife Service (USFWS) Lower Snake River Compensation Office, Shoshone-Bannock and Nez Perce Tribes, and other state and federal agencies and private groups interested in spring/summer chinook salmon restoration in the Snake River basin areas of Idaho and Oregon. Project information will be provided to CSCPTOC members at CSCPTOC meetings.